Spatial Range Munitions Constituents (MC) Modeling Capabilities

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Objectives

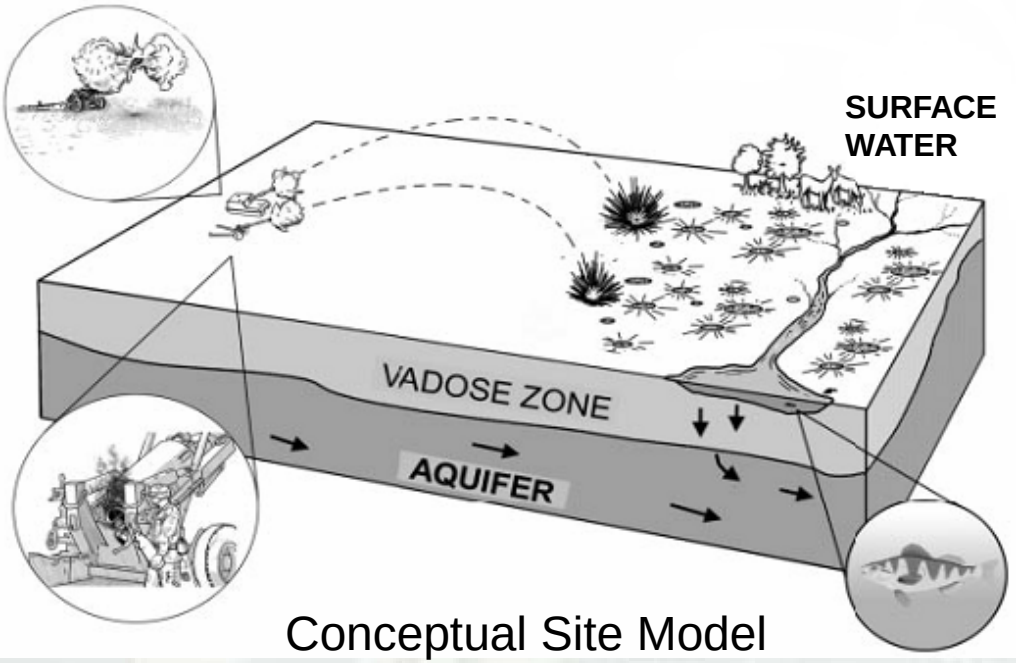
- Provide the range manager with tools that can be implemented to meet regulatory compliance goals and long-term sustainable management of the installation

- Develop, test and validate an integrated, multi-scale, multi-media, multi-pathway model for evaluation of distributed sources of munitions constituents (MC) on military testing and training lands

- Build and demonstrate a watershed application that represents full hydrologic processes, erosion /sedimentation, contaminant loadings, and instream water quality responses from military testing and training lands within and outside the Installation

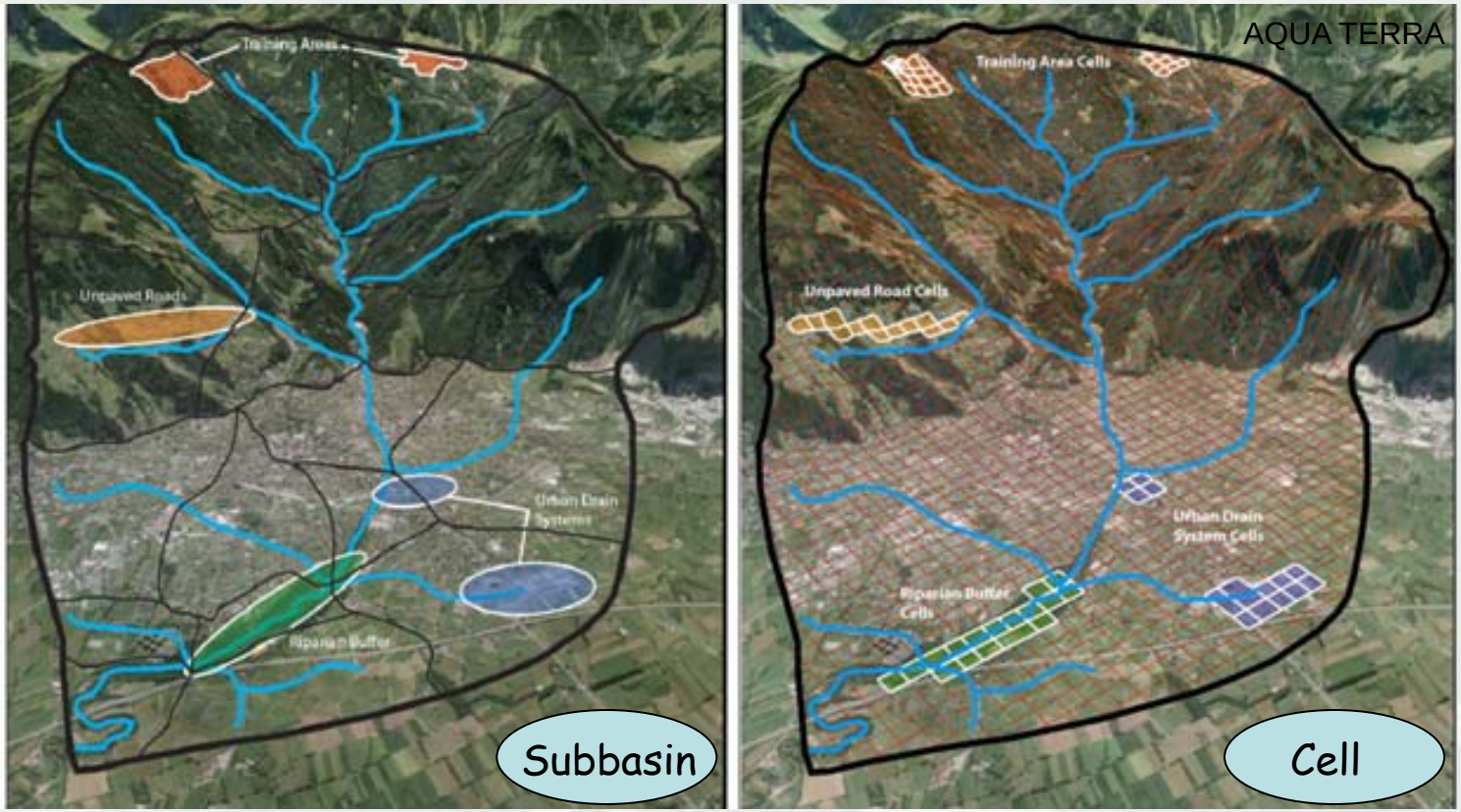
Background

- Potentially Contaminates of Concern (CoCs)
  - Explosives (RDX, TNT, HMX, DNT…)
  - Heavy metals (lead, cadmium, chromium, nickel, copper…)
- Potentially environmental issues
  - CoCs may be moving off range areas in sufficient concentration and contaminate surface water or ground water
  - People, plants and animals may be exposed to the CoCs, eventually pose a toxic threat to human health and ecosystems



Conceptual Site Model

Watershed Modeling



- HEC-HMS
- HSPF
- SWAT
- SWMM

- GSSHA
- DSVHM
- MIKE-SHE

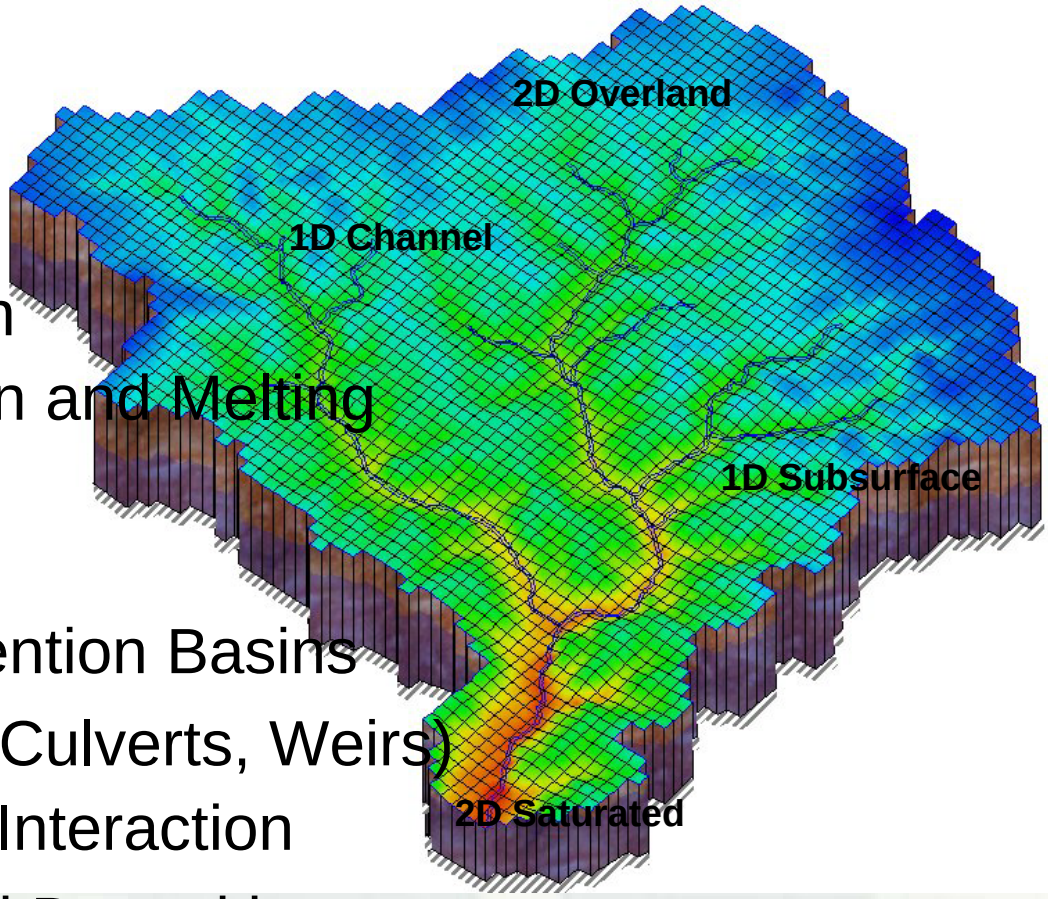
GSSHA

- **G**ridded **S**urface **S**ubsurface **H**ydrologic **A**nalysis
- Developed and maintained at the ERDC
- GSSHA is a physically based and fully distributed watershed model.
- GSSHA works on a uniform spatial grid.
- GSSHA closely links the hydrologic compartments at the watershed scale.
- GSSHA explicitly include spatially heterogeneous features, such as varying land use, source areas, BMPs, etc.
- GSSHA has been tested on a number of very different watersheds.

- http://gsshawiki.com

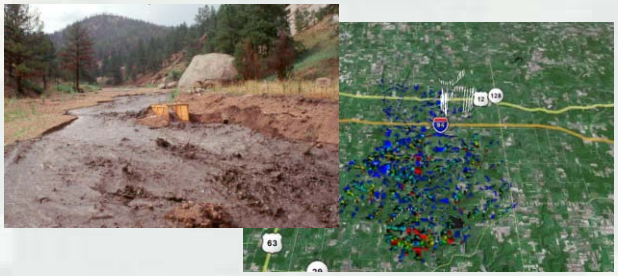
GSSHA

- 2D Overland Flow
- 1D Channel Network
- 2Dx1D Infiltration
- 2D Groundwater
- 2D Evapotranspiration
- Snowfall Accumulation and Melting
- Wetlands
- Storm/Tile Drains
- Small Lakes and Detention Basins
- Hydraulic Structures (Culverts, Weirs)
- Stream/Groundwater Interaction
- Sediment Erosion and Deposition



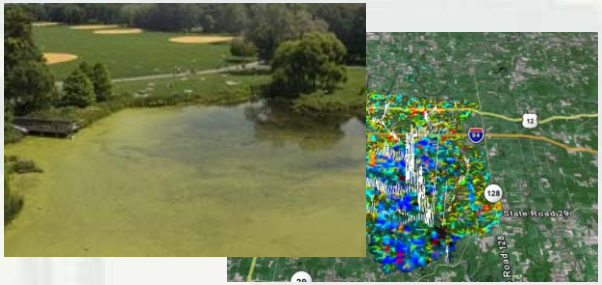
GSSHA Applications

Surface water hydrology



Sediment and Contaminant Transport

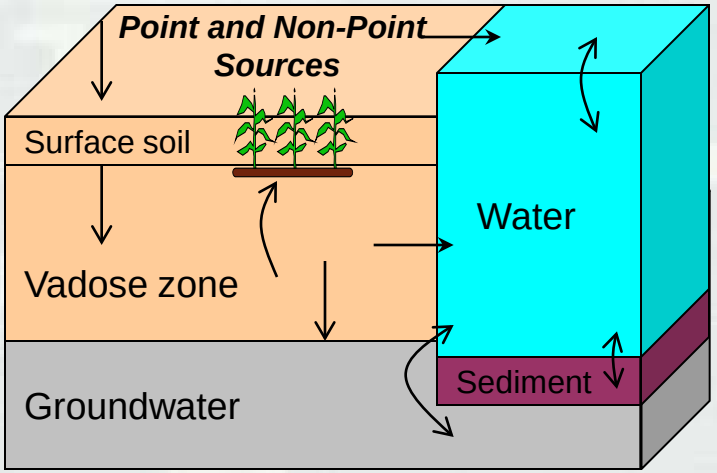
Surface Water/Groundwater Interaction



Surface water quality and TMDL's

Contaminant Transport, Transformation & Fate (CTT&F)

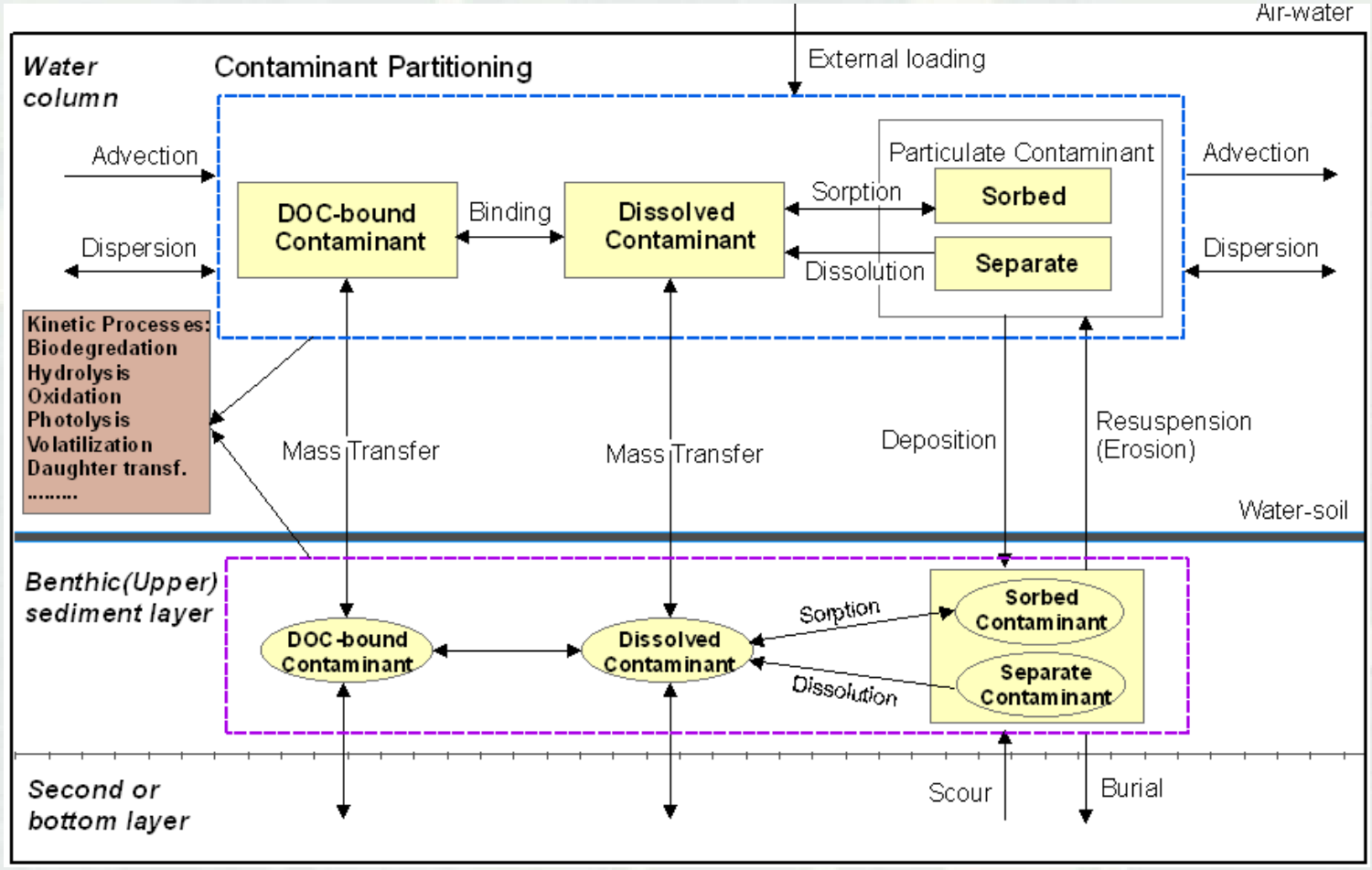
- GSSHA simulates surface runoff, interflow, baseflow and streamflow discharge, quantifies sediment rates of each grain size fraction for erosion from the soil surface and bed, and for deposition.
- **CTT&F** accounts for contaminant sources, movement, and chemical reactions for:
  - Surface runoff
  - Soil and interflow
  - Groundwater discharge
  - Streamflow

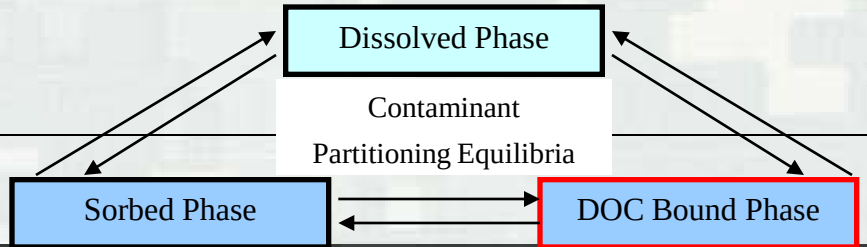


Current CTT&F Capabilities

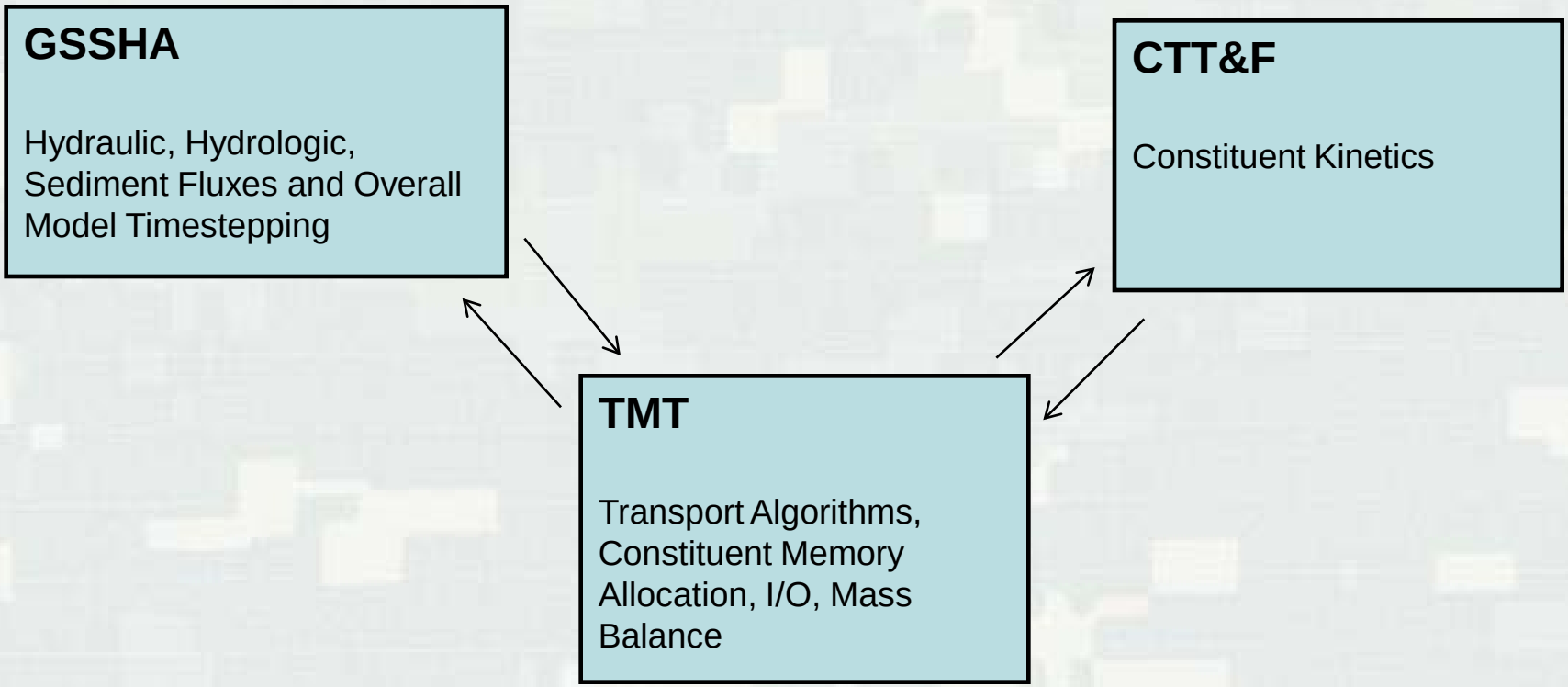
- Multiple (4) phase partitioning of MCs
  - Solids, Dissolved in water, Bound to DOC (Dissolved Organic Carbon), Sorbed to sediment particles
- Multi-media physical transport processes
  - Overland flow
  - Stream network
- Eight (8) biochemical transformation processes
  - Dissolution of solids
  - Biodegradation
  - Hydrolysis
  - Oxidation
  - Photolysis (Photodegradation)
  - Volatilization
  - User-defined extra reaction (second-order)
  - Transformations and daughter products

CTT&F Framework





Integrated GSSHA-CTT&F

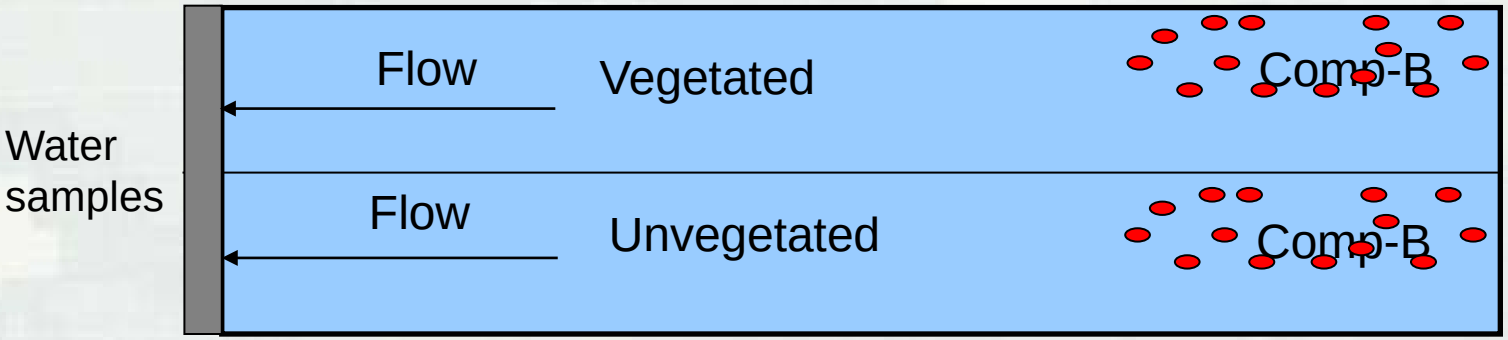


Facilitates the addition of new kinetic packages (e.g. NSM, Heavy Metals, Radionuclides, etc.) in the future.

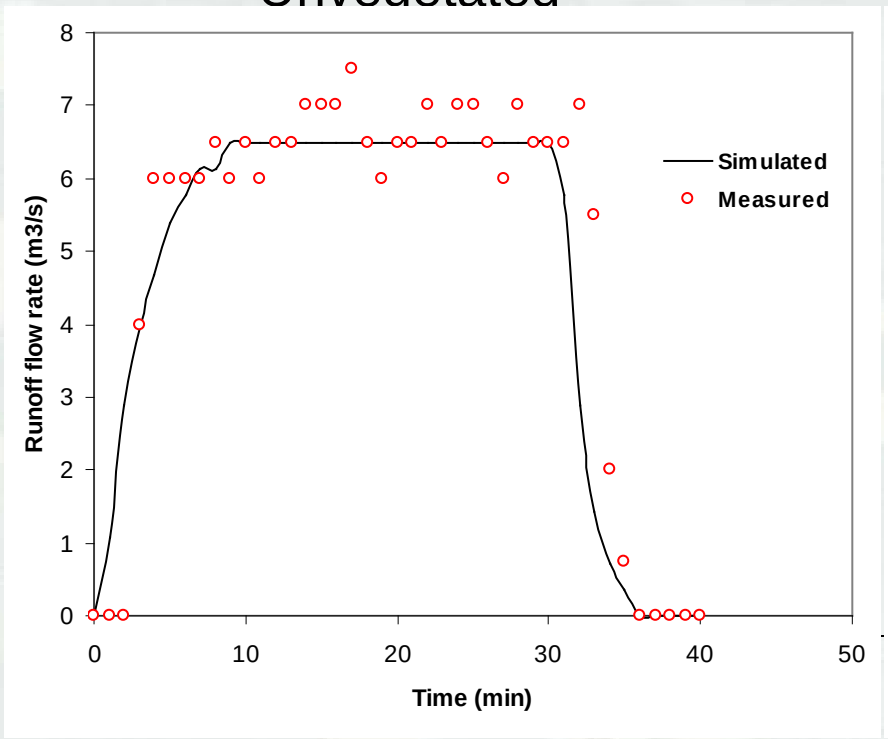
Model Testing & Validation

- Experiment plots was designed to simulate rainfall driven transport and transformations of explosives residues deposited on surface soils of firing ranges
- Explosive particles (Comp B) and RDX and TNT were modeled
- Two land covers were used to simulate two different surface roughness conditions: “disturbed” (unvegetated) and “undisturbed” (vegetated).
- Initial chemical loading: 500g / 67.5ft^2 = 79.73g / m^2.
- The rainfall (2.8 in/hr) corresponds to a 50 year rainfall event.

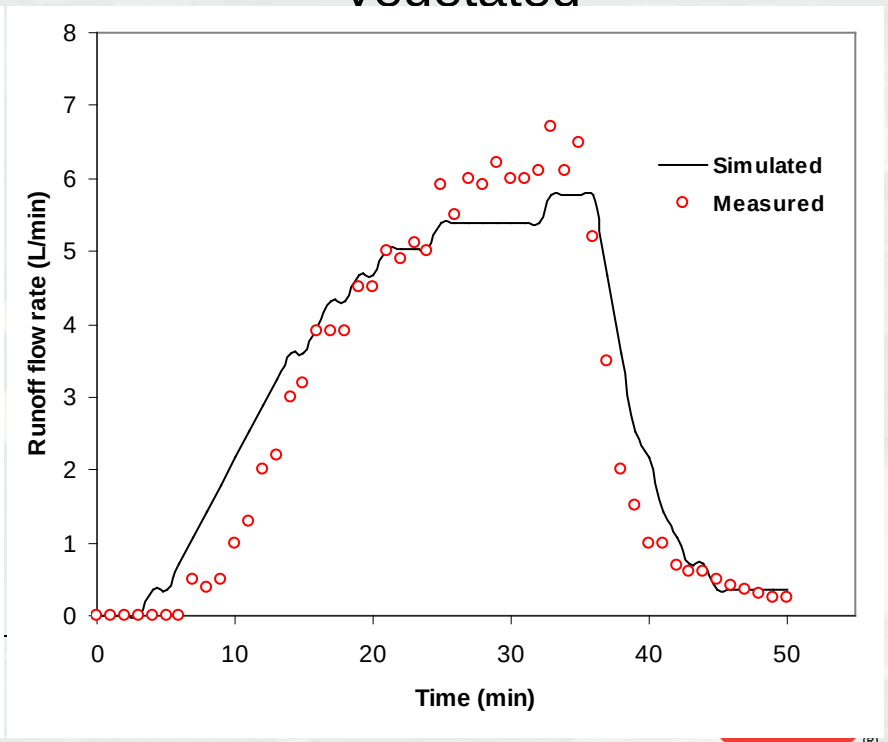
Model Testing & Validation



Unvegetated

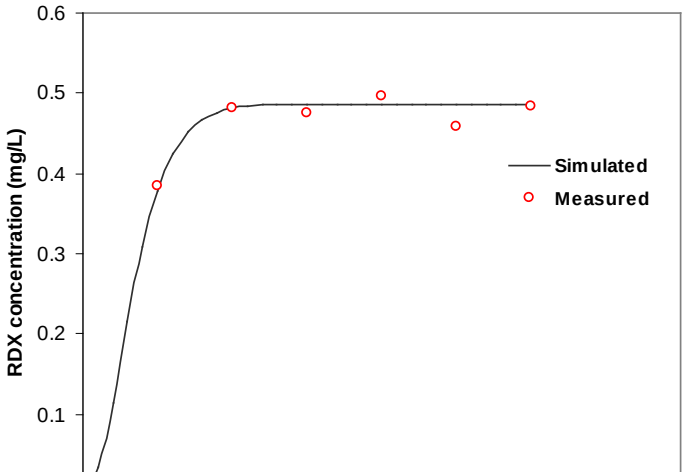


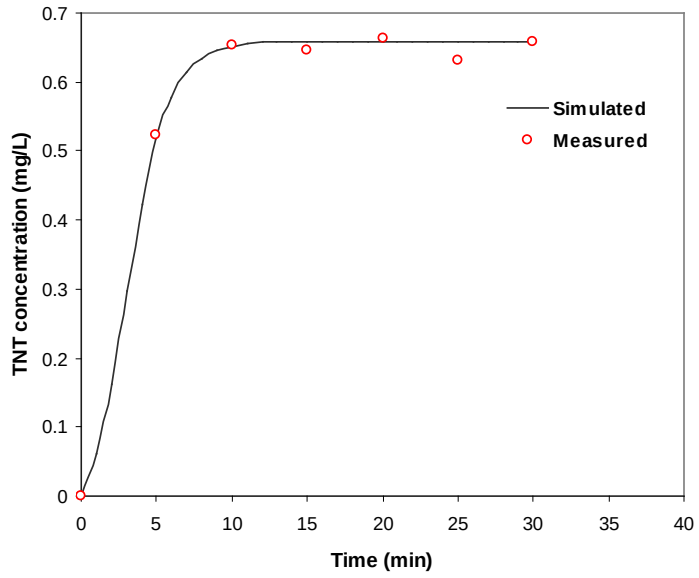
Vegetated

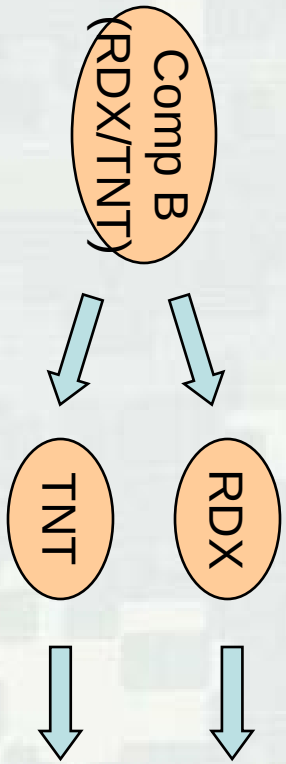


Model Testing & Validation

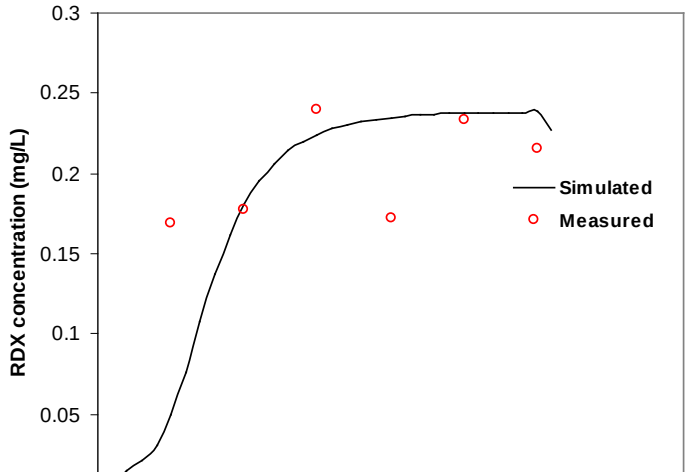
Unvegetated

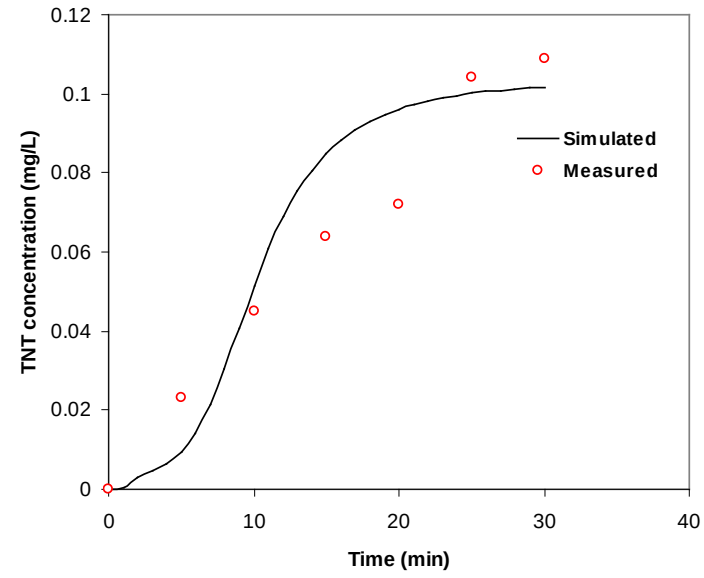






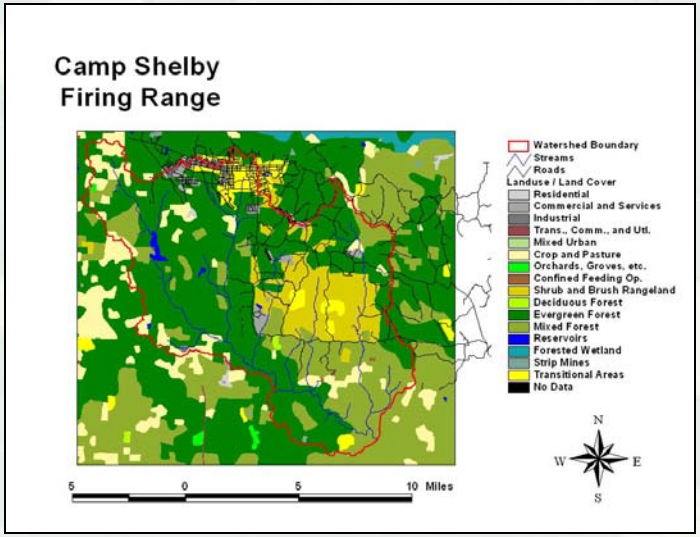
Vegetated

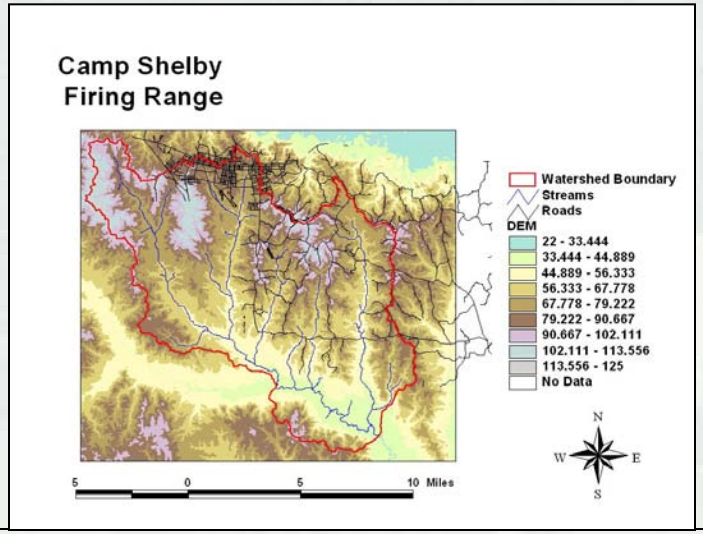


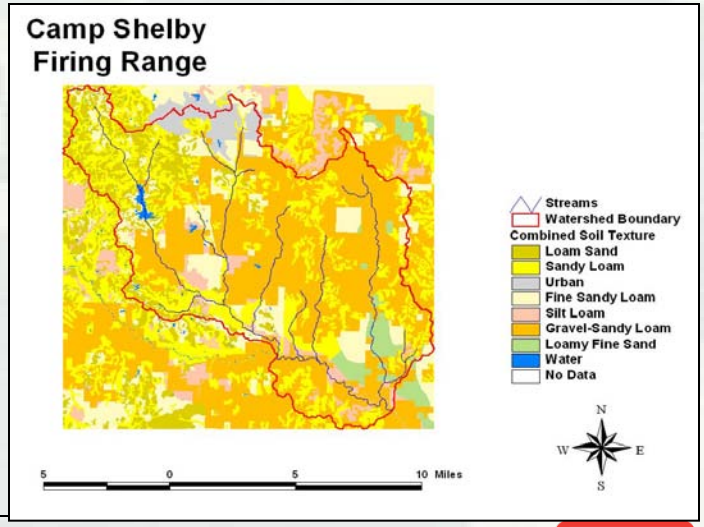


Watershed Application Demonstration

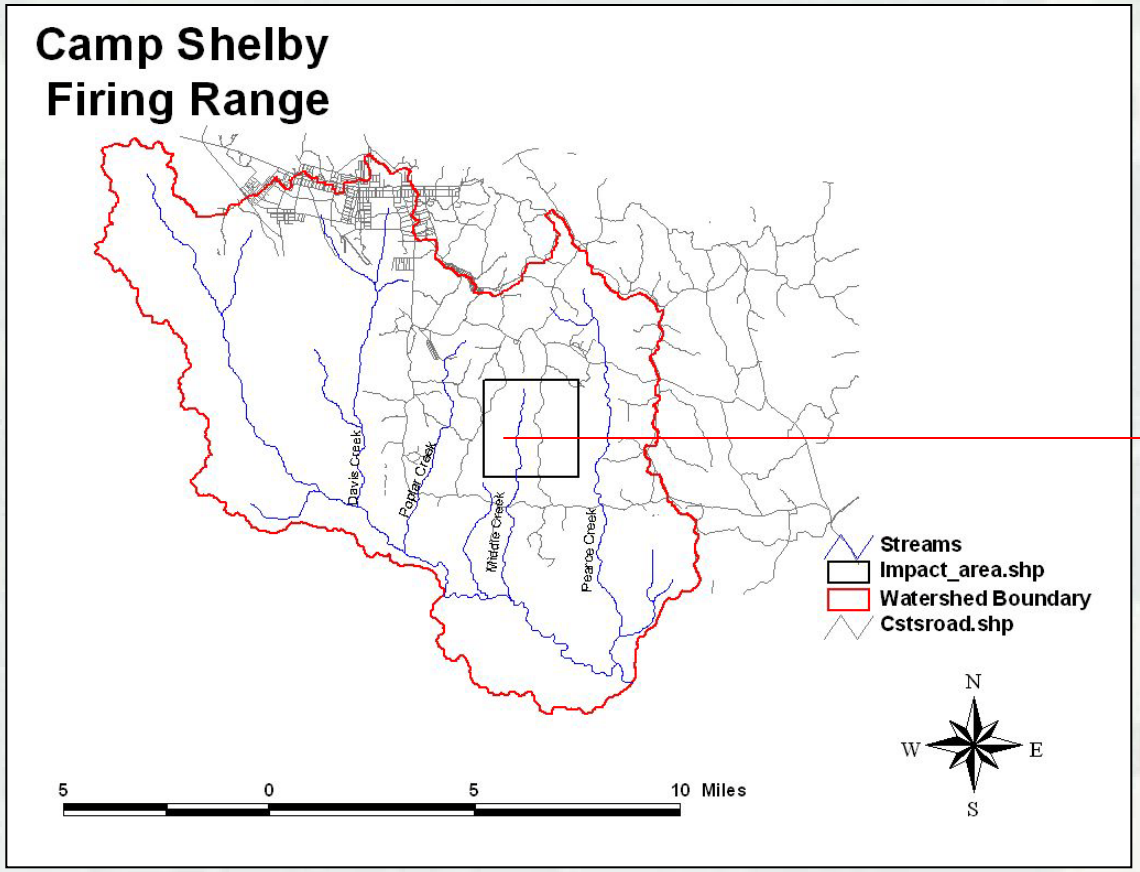
- Training Site is the largest reserve component training site, covering 136,000 acres, and a wide range of support facilities to support a variety of missions
- Watershed Area is approximately 112 square miles.



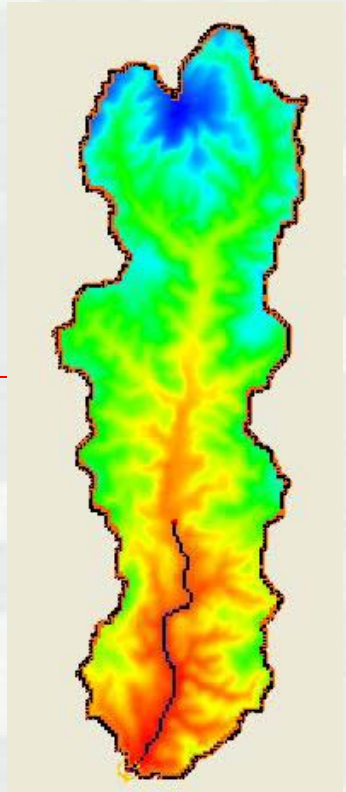




Watershed Application Demonstration

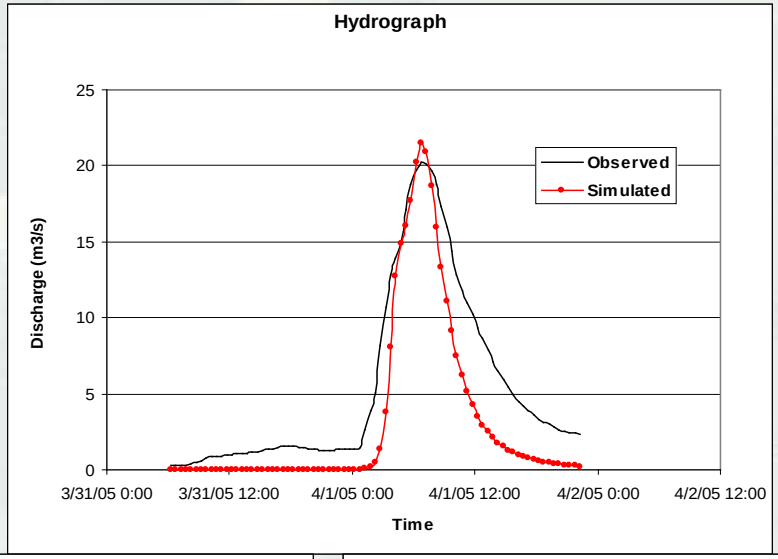


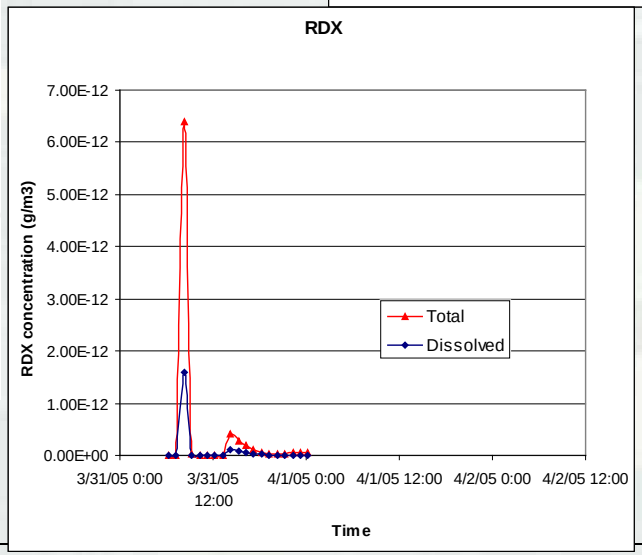
Middle Creek

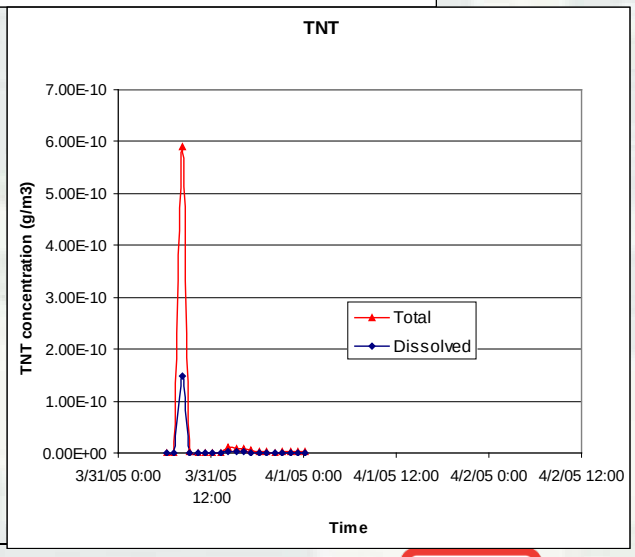


Drainage Area = 4.0 mi^2

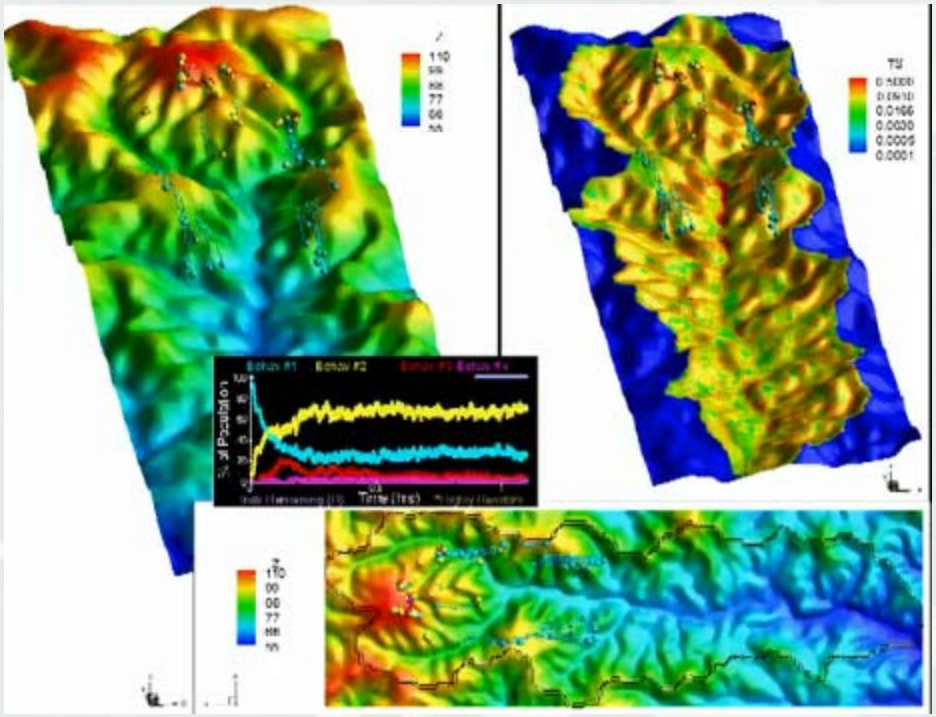
Watershed Application Demonstration







Watershed Application Demonstration



http://www.youtube.com/user/CognitiveEcologyTeam#p/u/3/kzbQMnbd20I

Summary

- GSSHA-CTT&F has been developed as a physically based, distributed, integrated watershed scale modeling system
- Application of the model to the training range indicates the GSSHA-CTT&F is a useful tool for predicting the site-specific behavior of explosives residue and multiple compounds
- The CTT&F algorithms and integration with GSSHA will be further validated directly against monitored range scale data
- Further development and enhancement of the CTT&F sub-model are underway.